Large scale morphological changes in the Hapi region on Comet 67P/Churyumov-Gerasimenko

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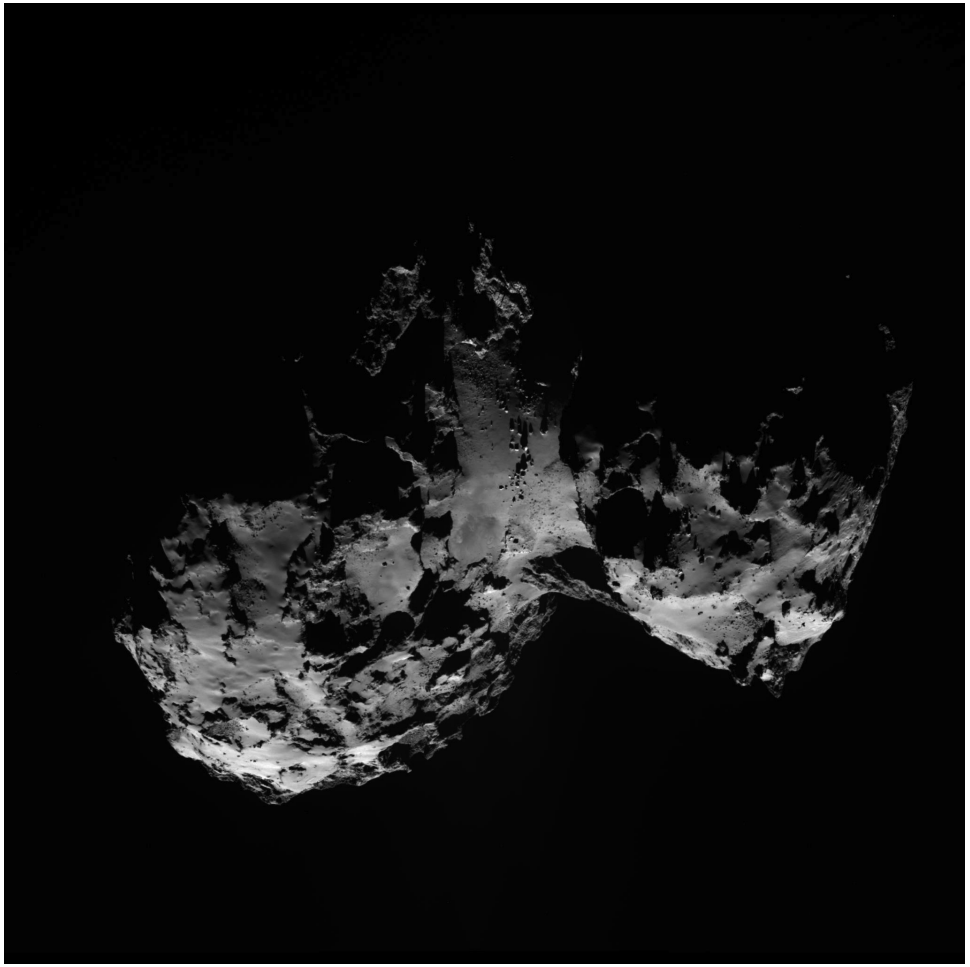
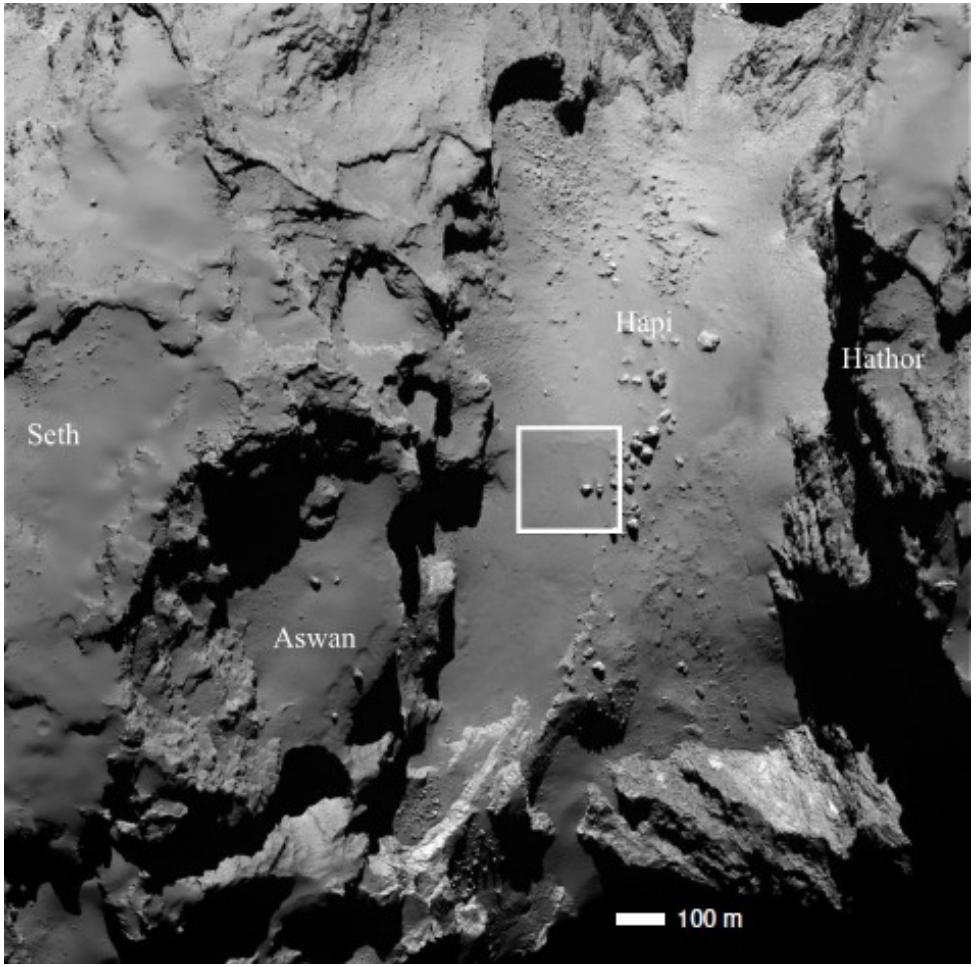
Summary

- OSIRIS detected large-scale changes in the Hapi region
  - Shallow pits in the Hapi region formed in late Dec 2014, grew to 75 x 110 x 0.5 m in the next two months
  - Why did this happen?

- MIRO measured nucleus thermal emission at 1.59 mm and 0.53 mm
  - Temperature versus time and depth
  - Thermal inertia, ice abundance, extinction and scattering coefficients
  - We find a thermal inertia of 100-200 MKS
  - We find a drastic drop in water abundance prior to pit formation
    - In the range 11-22% ice by mass in Oct 2014
    - Perhaps as little as 2% ice by mass in Nov 2014
- Work in progress....

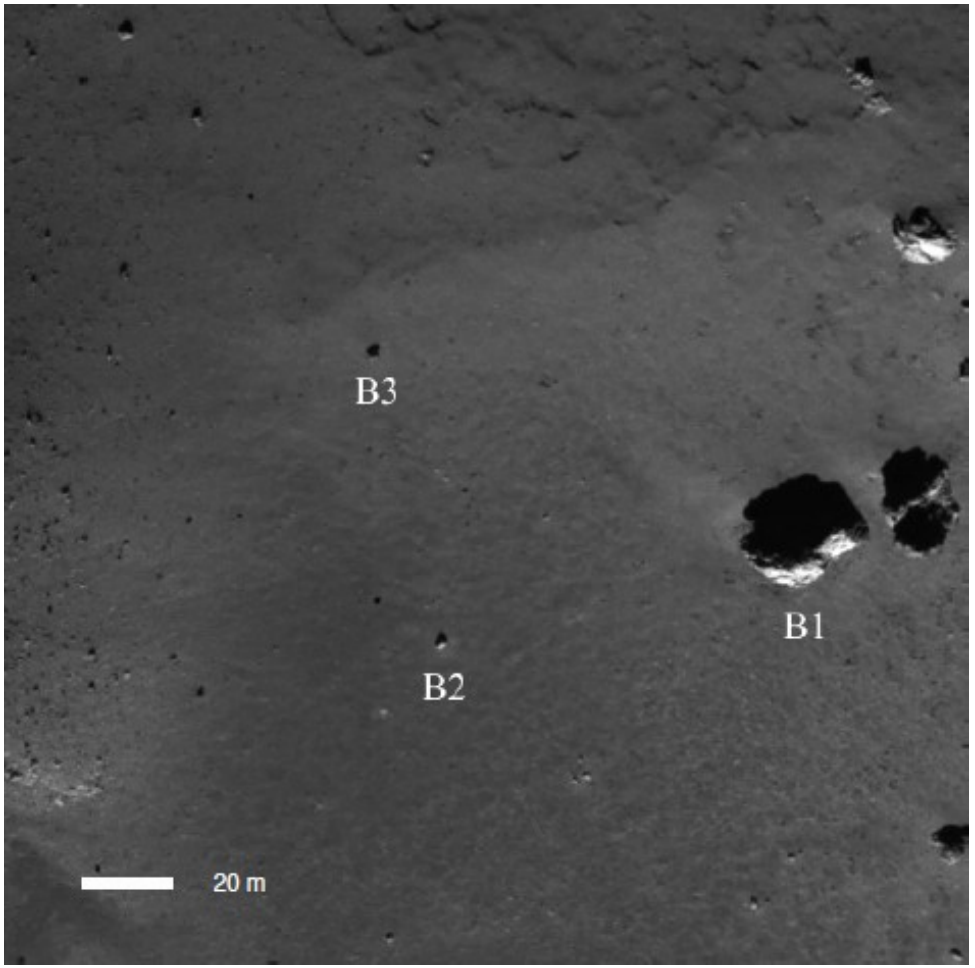
Context



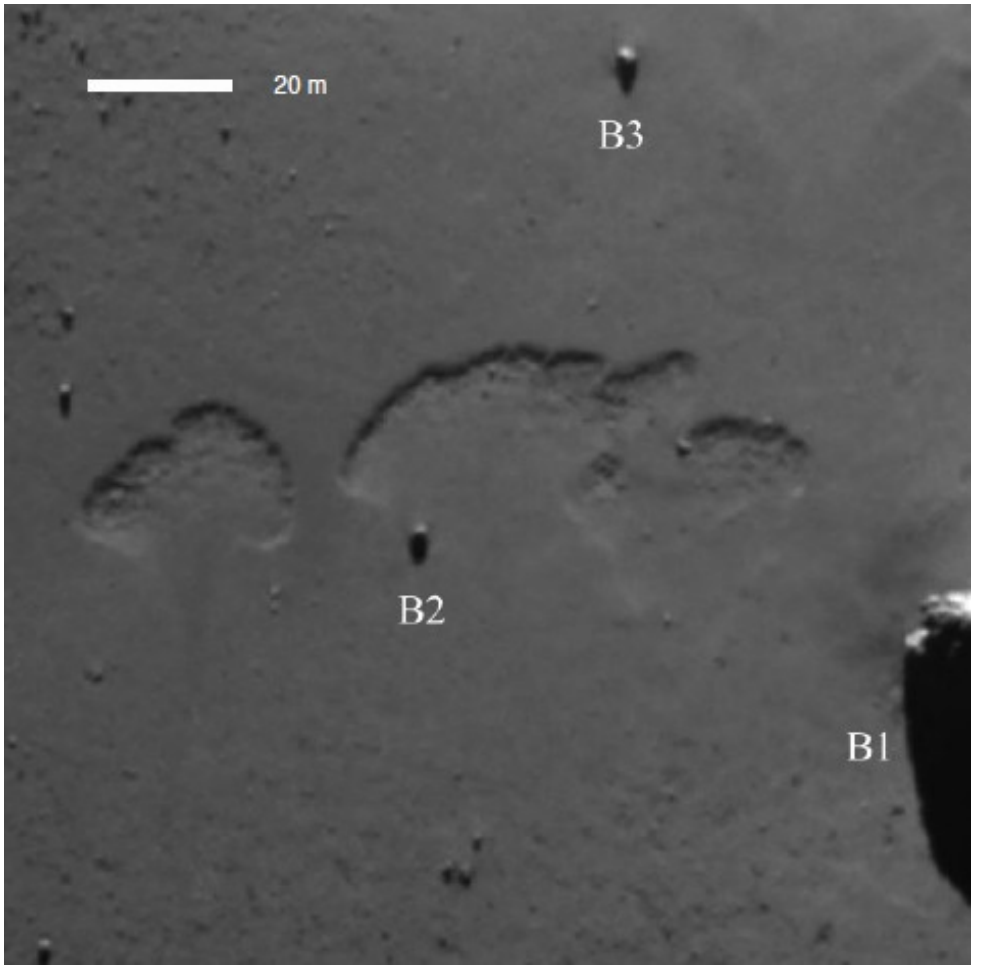


Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA and Davidsson *et al.* (2018, in preparation)

A large shallow depression emerges



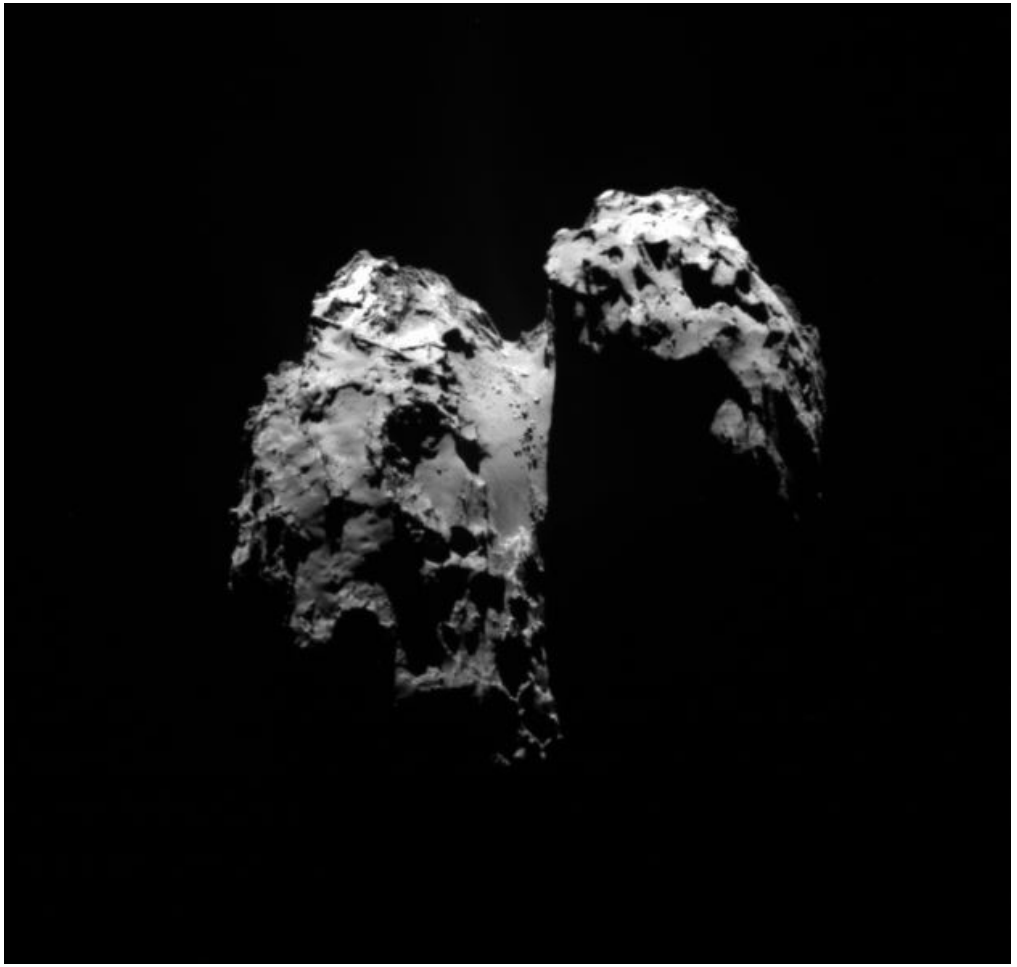
Dec 10, 2014. NAC 20 km: 0.35 m px^{-1}.



Jan 22, 2015. NAC 27km: 0.49 m px^{-1}.

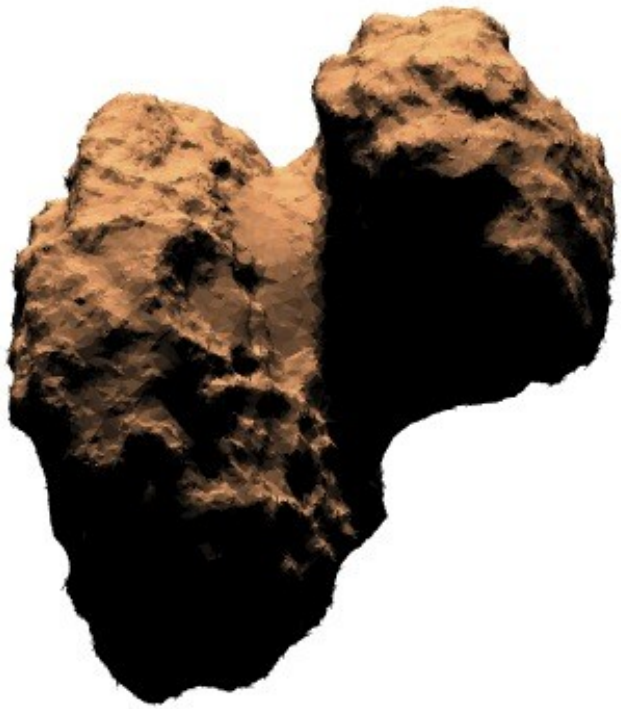
Credit: ESA/Rosetta/MPS for OSIRIS Team
MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA and Davidsson *et al.* (2018, in preparation)

Accurate illumination conditions throughout orbit



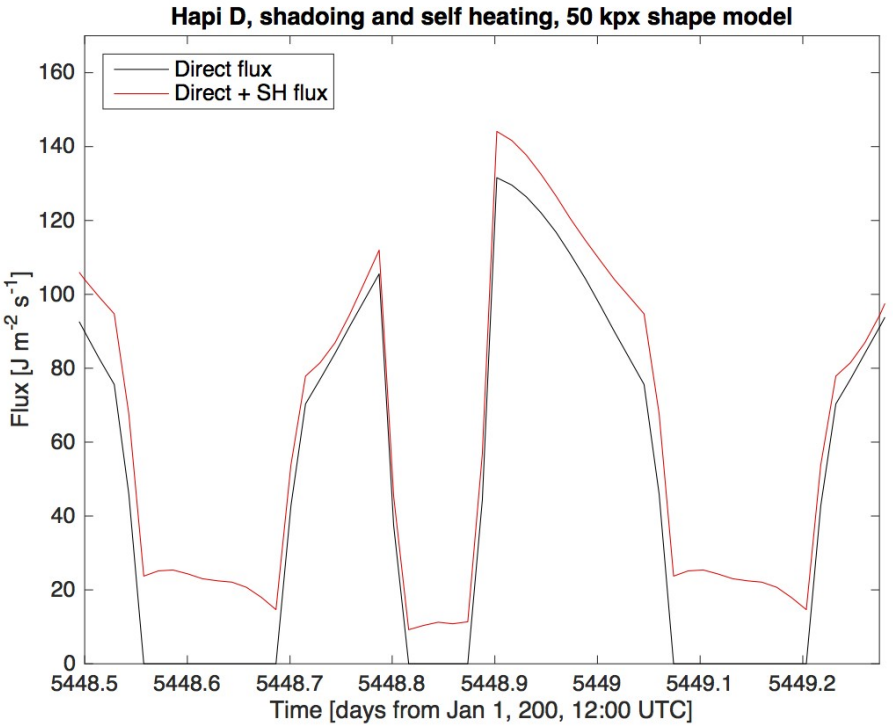
WAC image on Feb 9, 2015,
13:32:56.344 UTC

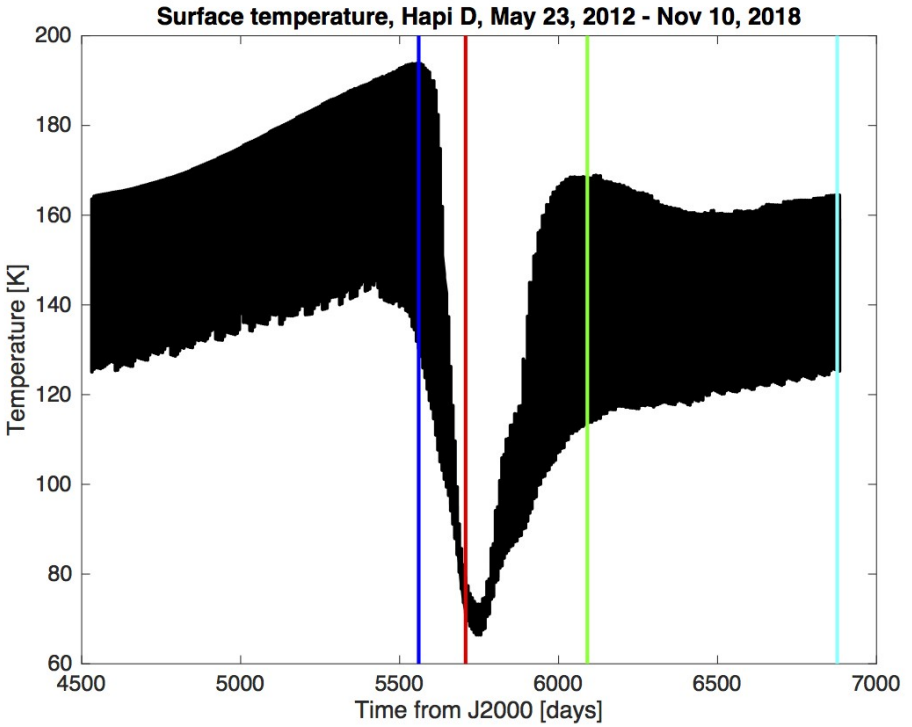
Credit: ESA/Rosetta/MPS for OSIRIS Team
MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA



Synthetic image generated with the model of Davidsson & Rickman (2014, *Icarus* **243**, 58-77)
Shape model SHAP5 version 1.5 (degraded) by Jorda *et al.* (2016, *Icarus*, **277**, 257-278)

Accurate illumination conditions throughout orbit





Credit: Davidsson

Shape model with 50,000 facets

Direct solar illumination and shadowing by topography

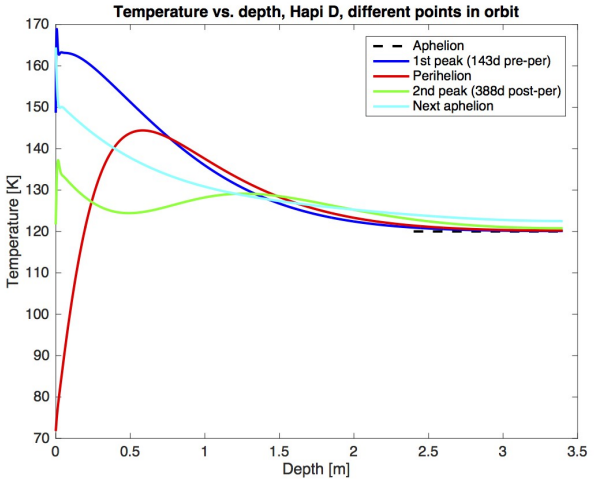
Vis+IR self-illumination from surrounding terrain.

10° rotational steps throughout orbit.

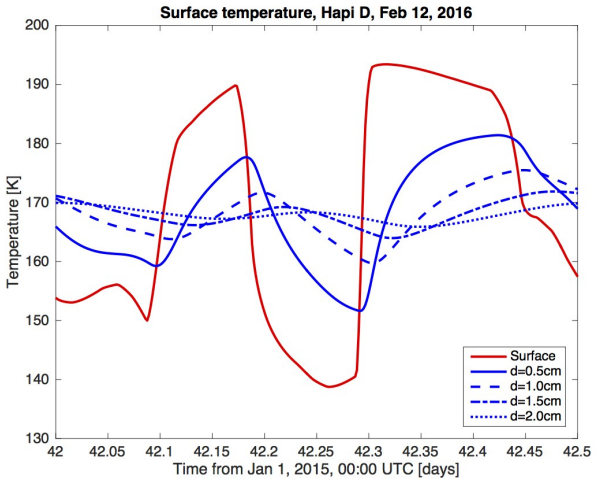
1D heat conduction equation with upper boundary condition balancing illumination, thermal emission, heat conduction, ice sublimation.

Temperature T versus depth x and time t. Start with 90K during 1959 Jupiter encounter, integrate until present.

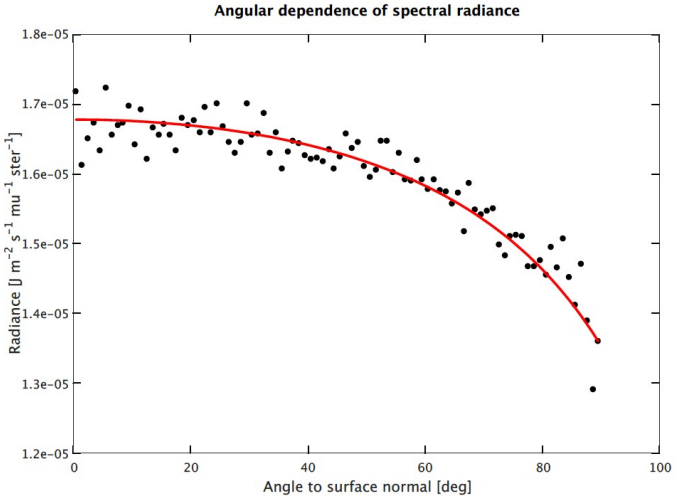
Thermophysics and radiative transfer



Modeling the upper 3.4 meters.
T=T(x) at different times during orbit.



T(t) for different depths for one comet day

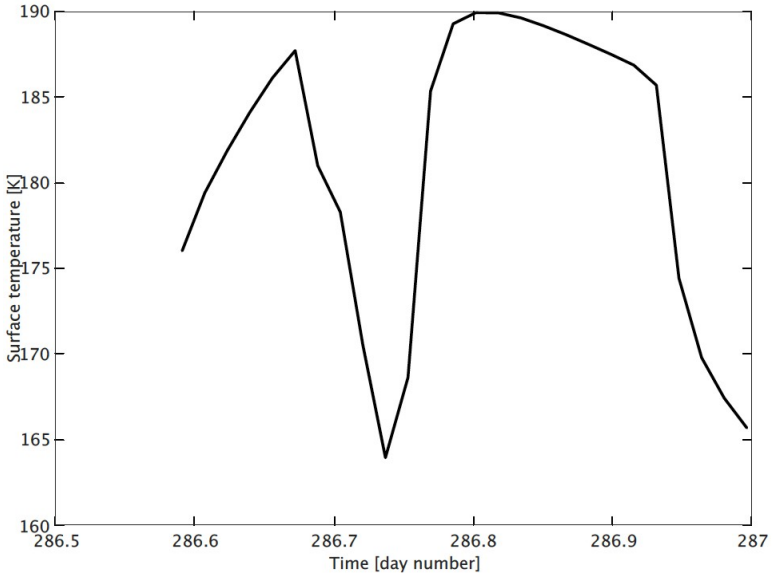


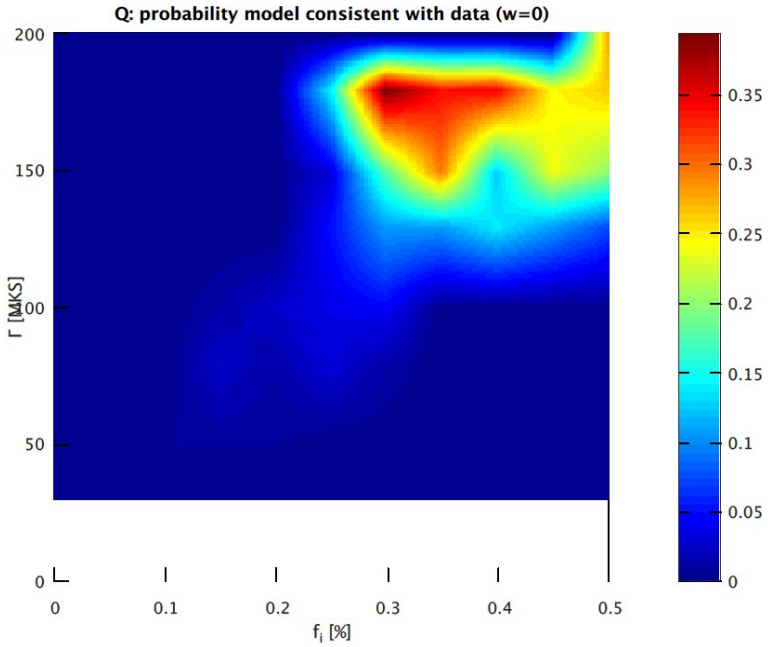
Temperature profile function of
* Ice abundance
* Thermal inertia

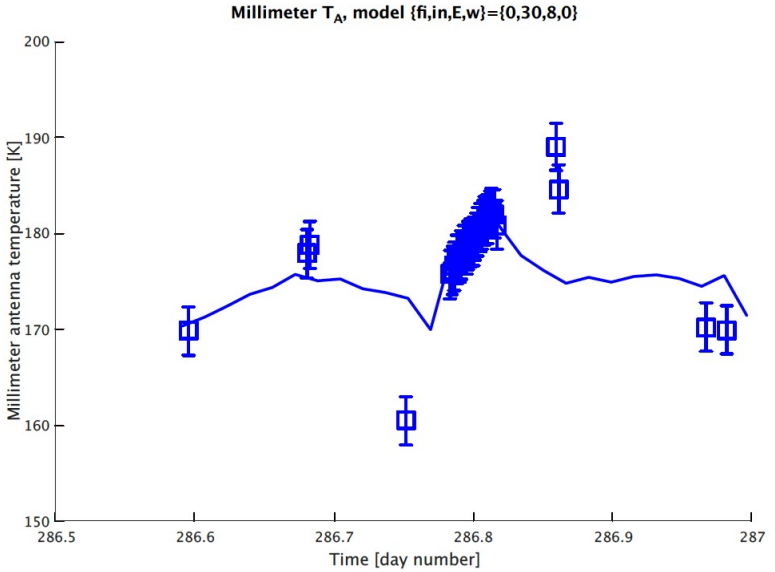
Inserted into radiative transfer solver to calculate mm and smm radiances measured by MIRO, presented as *antenna temperature.*
Function of (per wavelength)
* Extinction coefficient
* Single-scattering albedo

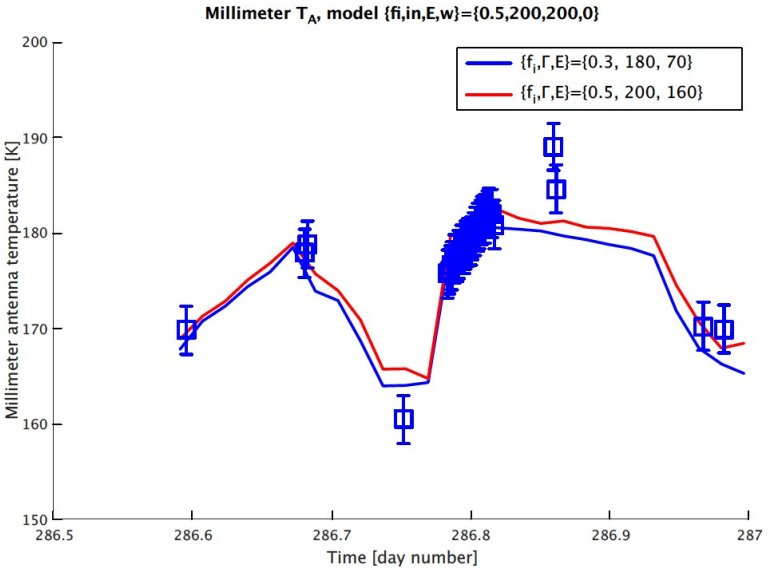
Credit: Davidsson

October 2014

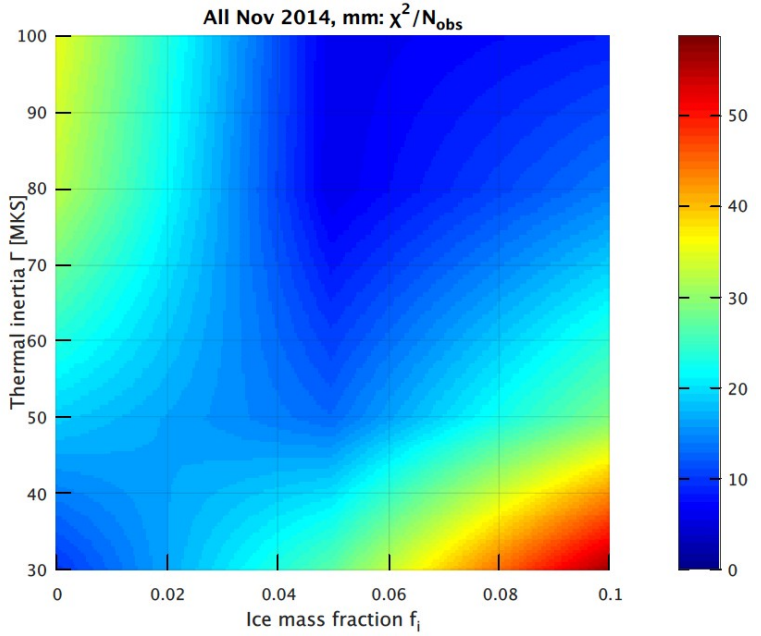


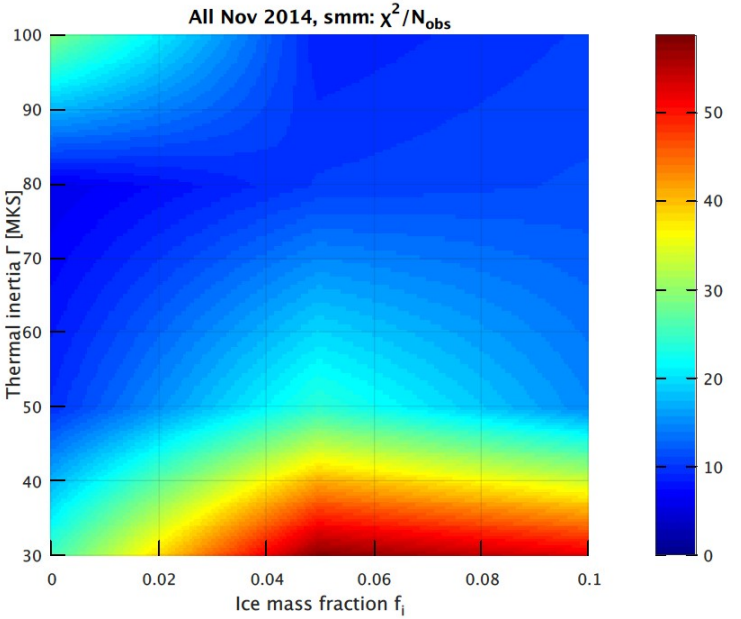


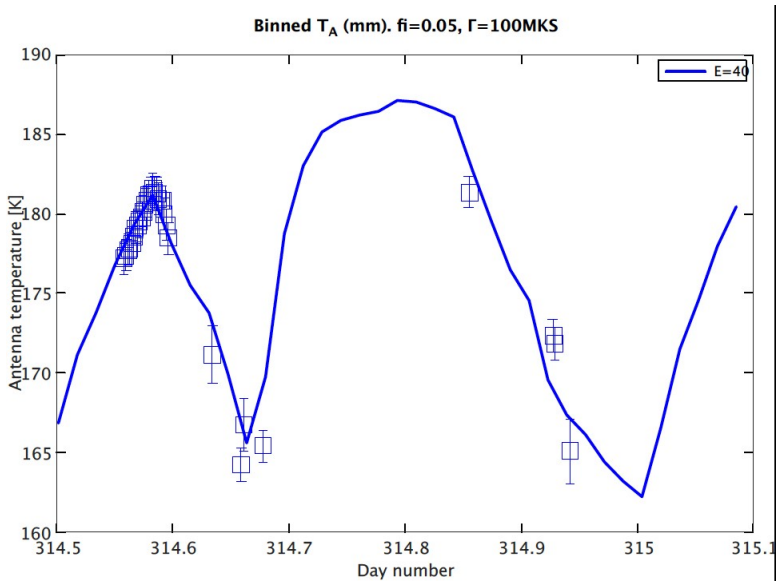


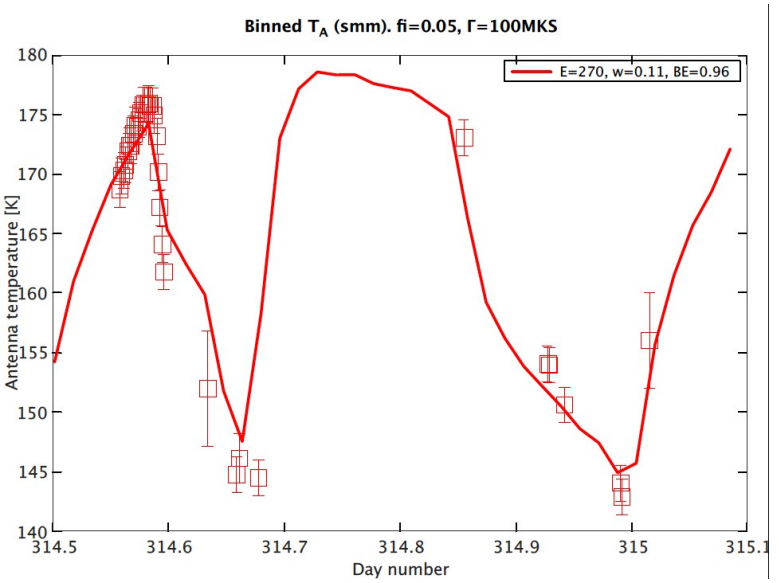


November 2014









Summary

- The October 2014 MIRO measurements are consistent with 30%-50% water ice by volume, or 11-22% by mass (dust/ice mass ratio μ = 3.5 - 8.1).
- The November 2014 MIRO measurements are consistent with perhaps as little as 5% water ice by volume (~2% by mass).
- Throughout the period the thermal inertia is in the range 100-200 MKS
- Rapid loss of water ice (binding material, weight) just prior to pit formation may be related to their formation